Section 5. PILE INSTALLATION BY VARIOUS DEVICES

1. UNDERWATER DRIVING. Commercial hammers which can be used for underwater driving are indicated in Table 4. Such hammers are available for use in depths of water up to 200 feet. The alternative of driving with a follower should be considered whenever underwater driving is contemplated. When driving underwater, use cylinder oil and other accessories as specified by the manufacturer for such purpose. Also, calculate the buoyant effect of the water on the submerged hammer and provide an equivalent deadweight on the hammer casing; otherwise, the energy of the blow will be reduced. Alternatively, increase the required driving resistance for hammer selection.

2. JETTING. Piles may be "sunk" into place by jetting which may, or may not, be accompanied by hammering on the pile or alternately raising and dropping the pile. Jetting also is used to relieve driving stresses, to save time, to obtain increased penetration of piles, and to decrease vibration incident to driving piles. Piles always should be driven to their final embedment after jetting has ceased.

a. Jets. (See Figure 16.)

(1) Fixed jets. Precast jets in concrete piles and concrete sheet piles may be used to avoid off-center and/or unsymmetrical jetting and the problem of keeping plumbness and alignment. This type of pile is costly but may be desirable where conditions do not permit using a loose pipe jet.

(2) Movable jets. Two jets symmetrically located give most rapid penetration and best control of the pile path.

b. Jet Pipes. Diameters (up to 4 inches) should be selected to meet the conditions in the field. Nozzle diameters should be from 3/4 to 1-1/2 inches.

c. Hose. Hose should be approximately 1/2 inch greater in diameter than the jet pipe and should have a protective jacket of canvas, cotton, or steel wires. Hose length should be as short as possible to minimize friction losses.

d. Pumps. Provide bronze fitted pumps exclusively.

(1) Capacity and pressures. Provide for pressure of 100 to 200 p.s.i. generally; 100 to 150 p.s.i. for gravel, and 40 to 60 p.s.i. for sand. Selection of capacity and pressure must provide a volume of water large enough to allow discharged water to rise along the sides of the pile for the full jetting depth.

(2) Design data. See Tables 7, 8 and 9 for data regarding pump sizes, discharges, and pressure losses in jet pipes and hoses.

e. Methods.

(1) Water Jetting. This is a method designed to discharge a water jet at the pile tip, with both volume of water and pressure sufficient to allow the discharge to come up around the pile.

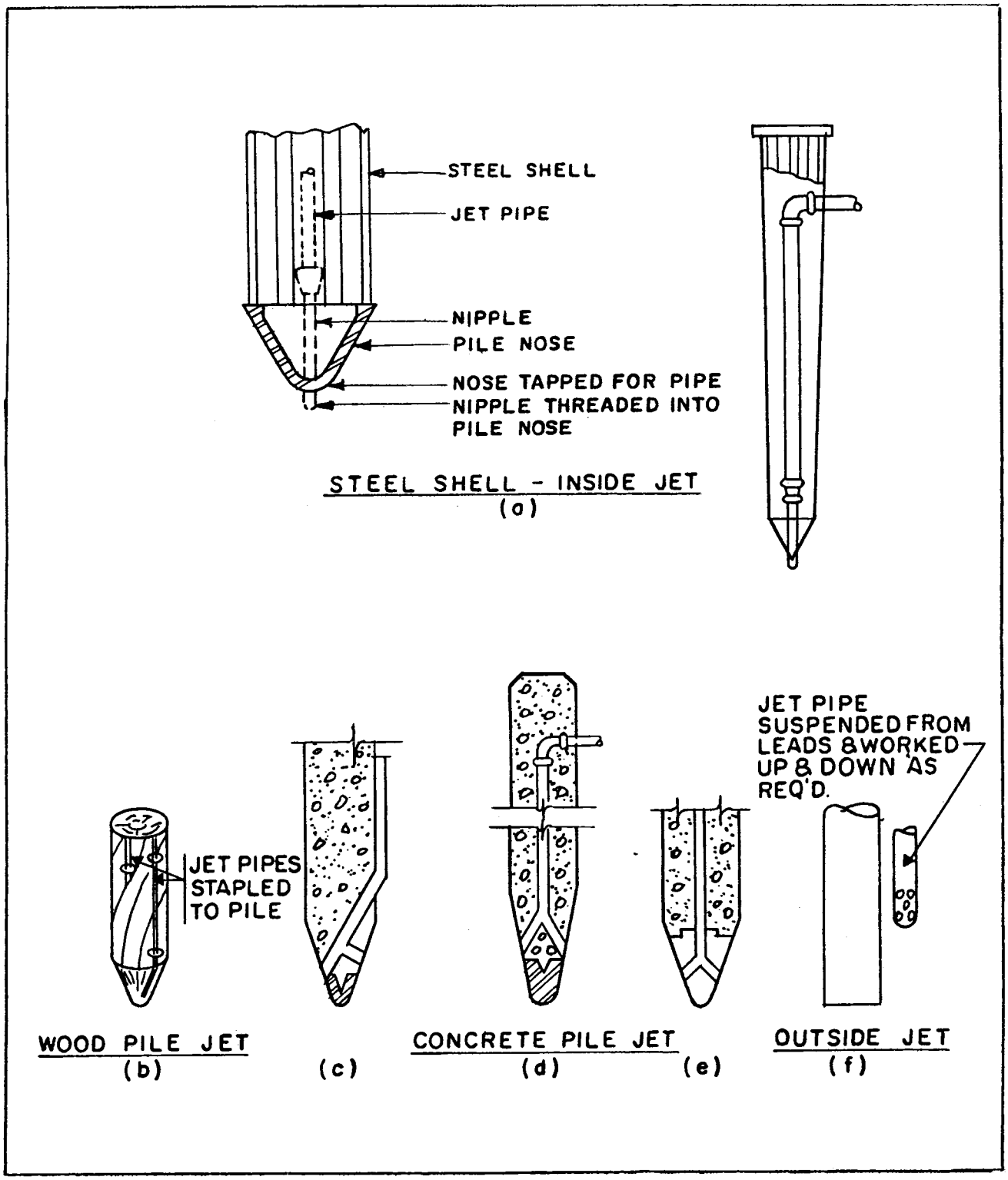

FIGURE 16
Typical Jetting Arrangements

TABLE 7
Size of Pumps Needed to Secure a Specified Discharge

g.p.m.	Steam Pressure (p.s.i.)	Discharge Pressure (p.s.i.)	Diam. of Steam Cylinder (in.)	Diam. of Water Cylinder (in.)	Stroke (in.)	Boiler hp. Required
175[1].....	100	175	10	6	10	45
225[2].....	100	200	10	7	10	60
345[3].....	100	175	12	8-1/2	12	90
500.....	100	175	14	8-1/2	15	145
800.....	100	175	17	10-1/4	15	200
1,000.....	100	175	20	12	12	250
500.....	100	175	12 + 18	8-1/2	12	100
800.....	100	175	14 + 20	10-1/4	15	140
1,000.....	100	175	16 + 25	12	18	175

[1]Duplex-packed piston pattern pump.
[2]Duplex-center-packed plunger pump, single steam end.
[3]Duplex-center-packed plunger pump, compound steam end.

TABLE 8
Approximate Discharge in Gallons Per Minute from Nozzles
Attached to 50 ft. of 2 1/2 in. Pipe or Hose

Pressure at pump (p.s.i.)	Size of Nozzle opening (in.)				
	3/4	1	1-1/4	1-3/8	1-1/2
100	160	275	400	460	515
150.....	195	340	495	570	640
200.....	220	395	580	670	740

(2) Spade or Multiple Jetting. This is a method for assisting the driving of sheet piling.

(3) Combined Air and Water Jetting. This method is useful when a double water jet and heavy driving cannot secure the desired penetration.

(4) Air Jetting. This method is practical for shallow depths, for probing or friction reduction, but not for deep penetrations.

TABLE 9
Loss of Pressure by Friction in Jet Pipe and Hose

Size of Pipe (in.)	Friction Loss, lb. per ft. of Length								
	100 (g.p.m.)	150 (g.p.m.)	200 (g.p.m.)	250 (g.p.m.)	300 (g.p.m.)	350 (g.p.m.)	400 (g.p.m.)	450 (g.p.m.)	500 (g.p.m.)
2	0.14	0.30	0.55	0.85	1.20	....	....	....	....
2-1/2	0.05	0.10	0.18	0.28	0.40	0.54	0.72	0.90	1.12
3	0.02	0.04	0.07	0.12	0.16	0.22	0.30	0.40	0.45
3-1/2	....	0.02	0.03	0.05	0.08	0.10	0.13	0.16	0.20
4	....	0.01	0.02	0.03	0.04	0.05	0.07	0.08	0.11
5	....	....	....	....	0.01	0.02	0.02	0.03	0.04
6	....	....	....	....	....	....	....	0.01	0.02

f. Limitations. Jetting applications are limited:

(1) In clay soils where plugging of the jets may occur.

(2) In cohesive soils where jetting is not useful or practical.

(3) In fine grained, poorly draining soils where jetting may loosen the soil around piles already driven.

(4) In locations where there is considerable ground water and the material disturbed by the jets cannot escape.

3. PREBORING, JACKING, SCREWING, AND PULL-DOWN METHODS. See Section 1 for descriptions. These methods of pile installation are used where soil conditions are such that the use of displacement piles is unsatisfactory (soils subject to heave) or where the vibrations or noise incident to pile driving must be avoided, or where overhead clearances are a problem.

4. SPECIAL CONSIDERATIONS RELATIVE TO INSTALLING PILES IN PERMAFROST AREAS.

a. General. Frozen soil is a material with considerable, often rock-like, strength. Unless steel "H" sections are used, installation of piles by conventional means (i.e., impact driving) often is impossible without excessive breakage, and resort is made to:

(1) Dropping the pile section into a dry augered hole or a hole opened by use of a rotary or churn drill and backfilling the hole with a soil-water slurry which, upon freezing, bonds to the pile.

(2) Steaming a thawed shaft into the ground; pressing or driving the pile into the thawed material, and allowing the thawed material to refreeze.

Piles in permafrost are not driven to resistance, but to specified penetration or tip elevation which is determined by the design engineer. The responsibilities of the persons installing the piles are:

(1) To obtain the necessary penetration.

(2) To use methods that will permit the soil around the pile to refreeze, quickly. The pile capacity (both resistance to downward loads and resistance to frost heave) depends on support from the surrounding soil which, in turn, requires that the soil adhere (adfreeze) to the pile. Until this adfreeze develops, only a fraction of the pile capacity is developed.

(3) To minimize disturbance to the permafrost, the ground cover, and the site in general. Any disturbance will upset the heat balance in the ground possibly causing (unless remedial measures are taken) thaw and refreezing with consequent settlement, followed by heave, which will affect buildings, pavements, and utilities. It may take years for the heat balance to be restored.

b. Site Preparation.

(1) If possible, restrict movement of pile placing equipment to perimeter of building so that the disturbed area will be accessible for the execution of remedial measures (placing of additional organic fill, for example).

(2) In the usual construction season, disturbance of the ground surface is likely to result in increased depth of thaw, which turns the site into a quagmire, making work difficult. Consider covering the area to be worked with a blanket of gravel or broken stone and working on top of the blanket.

c. Equipment.

(1) Steam jetting. Generally 3/4 inch to 1-1/4 inch pipe, open or slightly crimped at point to give better jetting action. In gravelly ground, chisel bit may facilitate penetration. Higher steam pressures (100-120 p.s.i.) are desirable. In "dry" soils, consider adding water to the hole during steaming to promote thawing. If the jet only opens a narrow hole, consider working jets alongside pile as pile is advanced.

(2) Augering or drilling. Truck mounted augers usually applicable in silts, clays, and some sands. In coarse sands and in soils containing cobbles, rotary or churn drilling or local prethawing may be required.

d. Cautions.

(1) In steam jetting method, carefully limit volume of thawed zone in order to minimize time for refreezing.

(2) In steam jetting or dry auger methods, slurry should be placed into hole at as near freezing temperature as feasible in order to minimize time for refreezing.

(3) In steam jetting or dry auger methods, seat pile firmly on bottom of hole to obtain partial capacity to support partial weight of construction while waiting for adfreeze to develop.